What Is Claimed Is:

1.   1.   A   method for I/Q mismatch calibration of a
2.   transmitter, comprising the following steps:
3.   generating a discrete-time signal $x[n] = x(n \cdot T_s)$, wherein
4. $x(t) = e^{j2\pi f_T t}$ and f_T and T_s are real numbers;
5.   obtaining a corrected signal $x_c[n]$ based on the signal $x[n]$
6.   and a set of correction parameters A_p and B_p, wherein
7. $x_c[n] = A_p \cdot x[n] + B_p \cdot x^*[n]$;
8.   converting the corrected signal $x_c[n]$ to an analog
9.   corrected signal $x_c(t)$;
10.   applying I/Q modulation to the analog corrected signal
11. $x_c(t)$ and outputting a modulated signal $x_m(t)$;
12.   obtaining a first desired component measure $W^{(1)}(f_T)$ and a
13.   first image component measure $W^{(1)}(-f_T)$ from the
14.   modulated signal $x_m(t)$ with a first set of the
15.   correction parameters A_p and B_p;
16.   obtaining a second desired component measure $W^{(2)}(f_T)$ and
17.   a second image component measure $W^{(2)}(-f_T)$ from the
18.   modulated signal $x_m(t)$ with a second set of the
19.   correction parameters A_p and B_p;
20.   obtaining a third desired component measure $W^{(3)}(f_T)$ and a
21.   third image component measure $W^{(3)}(-f_T)$ from the
22.   modulated signal $x_m(t)$ with a third set of the
23.   correction parameters A_p and B_p;
24.   obtaining a fourth and fifth set of correction parameters
25. A_p and B_p based on the first, the second, and the third
26.   desired component measures as well as the first, the
27.   second, and the third image component measures;

28   obtaining a fourth desired component measure $W^{(4)}(f_T)$ and
29   a fourth image component measure $W^{(4)}(-f_T)$ from the
30   modulated signal $x_m(t)$ with the fourth set of
31   correction parameters A_p and B_p;
32   obtaining a fifth desired component measure $W^{(5)}(f_T)$ and a
33   fifth image component measure $W^{(5)}(-f_T)$ from the
34   modulated signal $x_m(t)$ with the fifth set of
35   correction parameters A_p and B_p; and
36   obtaining a final set of the correction parameters A_p and
37   B_p from the fourth and fifth sets of correction
38   parameters.

1   2.   The method for I/Q mismatch calibration of a
2   transmitter as claimed in claim 1, wherein the first set of
3   correction parameters $(A_p, B_p) = (a, 0)$, the second set of
4   correction parameters $(A_p, B_p) = (b, b)$, and the third set of
5   correction parameters $(A_p, B_p) = (b, -b)$, where a and b are real
6   numbers.

1   3.   The method for I/Q mismatch calibration of a
2   transmitter as claimed in claim 2, wherein the parameter a is
3   1 and the parameter b is 1/2.

1   4.   The method for I/Q mismatch calibration of a
2   transmitter as claimed in claim 1, wherein the fourth set of
3   correction parameters (A_p, B_p) are obtained by

$$A_p = \sqrt{P} - j\hat{a}\sqrt{Q}$$
$$B_p = -\hat{a}\sqrt{P} - j\sqrt{Q}$$

5   and the fifth set of correction parameters (A_p, B_p) are
6   obtained by

7
$$A_p = \sqrt{P} + j\hat{\alpha}\sqrt{Q}$$
$$B_p = -\hat{\alpha}\sqrt{P} + j\sqrt{Q}$$

8   where

9
$$\alpha \approx \hat{\alpha} = \frac{\sqrt{N/O} - 1}{\sqrt{N/O} + 1},$$

10
$$N = (W^{(2)}(f_T) + W^{(2)}(-f_T))/2,$$

11
$$O = (W^{(3)}(f_T) + W^{(3)}(-f_T))/2,$$

12
$$Q = \frac{\hat{\alpha}^2 - \rho^{(1)}}{(1 + \rho^{(1)})(\hat{\alpha}^2 - 1)},$$

13
$$P = 1 - Q,$$

14
$$\rho^{(1)} = \frac{W^{(1)}(-f_T)}{W^{(1)}(f_T)}.$$

1   5. The method for I/Q mismatch calibration of a
2 transmitter as claimed in claim 1, wherein the final set of
3 correction parameters (A_p, B_p) is set to be the fourth set of
4 correction parameters if a function of $W^{(4)}(-f_T)$ is less than the
5 function of $W^{(5)}(-f_T)$, otherwise the final set of correction
6 parameters (A_p, B_p) is set to be the fifth set of correction
7 parameters.

1   6. The method for I/Q mismatch calibration of a
2 transmitter as claimed in claim 5, wherein the final set of
3 correction parameters (A_p, B_p) is set to be the fourth set of
4 correction parameters if $W^{(4)}(-f_T)$ is less than $W^{(5)}(-f_T)$,
5 otherwise the final set of correction parameters (A_p, B_p) is set
6 to be the fifth set of correction parameters.

1   7. The method for I/Q mismatch calibration of a
2   transmitter as claimed in claim 1, wherein the final set of
3   correction parameters (A_p, B_p) is set to be the fourth set of
4   correction parameters if a function of $W^{(4)}(f_T)$ is greater than
5   the function of $W^{(5)}(f_T)$, otherwise the final set of correction
6   parameters (A_p, B_p) is set to be the fifth set of correction
7   parameters.

1   8. The method for I/Q mismatch calibration of a
2   transmitter as claimed in claim 7, wherein the final set of
3   correction parameters (A_p, B_p) is set to be the fourth set of
4   correction parameters if $W^{(4)}(f_T)$ is greater than $W^{(5)}(f_T)$,
5   otherwise the final set of correction parameters (A_p, B_p) is set
6   to be the fifth set of correction parameters.

1   9. The method for I/Q mismatch calibration of a
2   transmitter as claimed in claim 1, wherein the final set of
3   correction parameters (A_p, B_p) is set to be the fourth set of
4   correction parameters if a function of $W^{(4)}(-f_T)$ and $W^{(4)}(f_T)$ is
5   less than the function of $W^{(5)}(-f_T)$ and $W^{(5)}(f_T)$, otherwise the
6   final set of correction parameters (A_p, B_p) is set to be the fifth
7   set of correction parameters.

1   10. The method for I/Q mismatch calibration of a
2   transmitter as claimed in claim 9, wherein the final set of
3   correction parameters (A_p, B_p) is set to be the fourth set of
4   correction parameters if $W^{(4)}(-f_T)/W^{(4)}(f_T)$ is less than
5    $W^{(5)}(-f_T)/W^{(5)}(f_T)$, otherwise the final set of correction
6   parameters (A_p, B_p) is set to be the fifth set of correction
7   parameters.

1   11. The method for I/Q mismatch calibration of a
2   transmitter as claimed in claim 1, further comprising the
3   following steps:
4   further adding an DC compensation parameter γ_p while
5   obtaining the corrected signal $x_c[n]$ such that
6                $x_c[n] = A_p \cdot (x[n] + \gamma_p) + B_p \cdot (x[n] + \gamma_p)^*$;
7   obtaining a first local leakage component measure L_1 from
8   the modulated signal $x_m(t)$ with the final set of
9   parameters A_p and B_p, and the parameter $\gamma_p = \zeta_1$, where
10   ζ_1 is a real number;
11   obtaining a second local leakage component measure L_2 from
12   the modulated signal $x_m(t)$ with the final set of
13   parameters A_p and B_p, and the parameter $\gamma_p = \zeta_2$, where
14   ζ_2 is a real number;
15   obtaining a third local leakage component measure L_3 from
16   the modulated signal $x_m(t)$ with the final set of
17   parameters A_p and B_p, and the parameter $\gamma_p = j\zeta_1$;
18   obtaining a fourth local leakage component measure L_4 from
19   the modulated signal $x_m(t)$ with the final set of
20   parameters A_p and B_p, and the parameter $\gamma_p = j\zeta_2$;
21   obtaining a fifth local leakage component measure L_5 from
22   the modulated signal $x_m(t)$ with the final set of
23   parameters A_p and B_p, and the parameter $\gamma_p = 0$; and
24   obtaining a final DC compensation parameter $\gamma_{p,final}$ based on
25   the first local leakage component measure L_1, the
26   second local leakage component measure L_2, the third
27   local leakage component measure L_3, the fourth local
28   leakage component measure L_4 and the fifth local
29   leakage component measure L_5.

1   12. The method for I/Q mismatch calibration of a
2   transmitter as claimed in claim 11, wherein the final DC
3   compensation parameter $\gamma_{p,final}$ is obtained by

4    $$\gamma_{p,final} = -\frac{1}{2}\cdot\frac{\zeta_2^2(L_1-L_5)-\zeta_1^2(L_2-L_5)}{\zeta_1(L_2-L_5)-\zeta_2(L_1-L_5)} - j\frac{1}{2}\cdot\frac{\zeta_2^2(L_3-L_5)-\zeta_1^2(L_4-L_5)}{\zeta_1(L_4-L_5)-\zeta_2(L_3-L_5)}.$$

1   13. An apparatus for I/Q mismatch calibration of a
2   transmitter, comprising:
3   a signal generator for generating a discrete-time signal
4            $x[n]=x(n\cdot T_s)$, wherein $x(t)=e^{j2\pi f_T t}$ and f_T and T_s are real
5   numbers;
6   a correction module for receiving the discrete-time signal
7            $x[n]$ and obtaining a corrected signal $x_c[n]$ based on
8   the test signal $x[n]$ and a set of correction
9   parameters A_p and B_p, wherein $x_c[n]=A_p\cdot x[n]+B_p\cdot x^*[n]$;
10   a first and second D/A converter converting the corrected
11   signal $x_c[n]$ to an analog signal $x_c(t)$, wherein the
12   first D/A converter converts the real part of the
13   corrected signal to the real part of the analog
14   signal, and the second D/A converter converts the
15   imaginary part of the corrected signal to the
16   imaginary part of the analog signal;
17   a modulator applying I/Q modulation to the analog signal
18           $x_c(t)$, and outputting a modulated signal $x_m(t)$;
19   a measurer for implementing the steps of:
20   obtaining a first desired component measure $W^{(1)}(f_T)$
21   and a first image component measure $W^{(1)}(-f_T)$
22   from the modulated signal $x_m(t)$ with a first set
23   of the correction parameters A_p and B_p;

24   obtaining a second desired component measure $W^{(2)}(f_T)$

25   and a second image component measure $W^{(2)}(-f_T)$

26   from the modulated signal $x_m(t)$ with a second

27   set of the correction parameters A_p and B_p;

28   obtaining a third desired component measure $W^{(3)}(f_T)$

29   and a third image component measure $W^{(3)}(-f_T)$

30   from the modulated signal $x_m(t)$ with a third set

31   of the correction parameters A_p and B_p;

32   obtaining a fourth desired component measure

33    $W^{(4)}(f_T)$ and a fourth image component measure

34    $W^{(4)}(-f_T)$ from the modulated signal $x_m(t)$ with a

35   fourth set of correction parameters A_p and B_p;

36   and

37   obtaining a fifth desired component measure $W^{(5)}(f_T)$

38   and a fifth image component measure $W^{(5)}(-f_T)$

39   from the modulated signal $x_m(t)$ with a fifth set

40   of correction parameters A_p and B_p; and

41 a processor for implementing the steps of:

42   obtaining the fourth and fifth sets of correction

43   parameters A_p and B_p based on the first, the

44   second, and the third desired component

45   measures as well as the first, the second, and

46   the third image component measures; and

47   choosing a final set of correction parameters A_p and

48   B_p from the fourth and fifth sets of correction

49   parameters.

1 14. The apparatus for I/Q mismatch calibration of a

2 transmitter as claimed in claim 13, wherein the first set of

3 correction parameters $(A_p, B_p) = (a, 0)$, the second set of

correction parameters $(A_p, B_p) = (b, b)$, and the third set of correction parameters $(A_p, B_p) = (b, -b)$, where a and b are real numbers.

15. The apparatus for I/Q mismatch calibration of a transmitter as claimed in claim 13, wherein the parameter a is 1 and the parameter b is 1/2.

16. The apparatus for I/Q mismatch calibration of a transmitter as claimed in claim 13, wherein the fourth set of correction parameters (A_p, B_p) are obtained by

$$A_p = \sqrt{P} - j\hat{\alpha}\sqrt{Q}$$
$$B_p = -\hat{\alpha}\sqrt{P} - j\sqrt{Q}$$

and the fifth set of correction parameters (A_p, B_p) are obtained by

$$A_p = \sqrt{P} + j\hat{\alpha}\sqrt{Q}$$
$$B_p = -\hat{\alpha}\sqrt{P} + j\sqrt{Q}$$

where

$$\alpha \approx \hat{\alpha} = \frac{\sqrt{N/O} - 1}{\sqrt{N/O} + 1},$$

$$N = (W^{(2)}(f_T) + W^{(2)}(-f_T))/2,$$

$$O = (W^{(3)}(f_T) + W^{(3)}(-f_T))/2,$$

$$Q = \frac{\hat{\alpha}^2 - \rho^{(1)}}{(1 + \rho^{(1)})(\hat{\alpha}^2 - 1)},$$

$$P = 1 - Q,$$

$$\rho^{(1)} = \frac{W^{(1)}(-f_T)}{W^{(1)}(f_T)}.$$

1   17. The apparatus for I/Q mismatch calibration of a
2   transmitter as claimed in claim 13, wherein the final set of
3   correction parameters (A_p, B_p) is set to be the fourth set of
4   correction parameters if a function of $W^{(4)}(-f_T)$ is less than the
5   function of $W^{(5)}(-f_T)$, otherwise the final set of correction
6   parameters (A_p, B_p) is set to be the fifth set of correction
7   parameters.

1   18. The apparatus for I/Q mismatch calibration of a
2   transmitter as claimed in claim 17, wherein the final set of
3   correction parameters (A_p, B_p) is set to be the fourth set of
4   correction parameters if $W^{(4)}(-f_T)$ is less than $W^{(5)}(-f_T)$,
5   otherwise the final set of correction parameters (A_p, B_p) is set
6   to be the fifth set of correction parameters.

1   19. The apparatus for I/Q mismatch calibration of a
2   transmitter as claimed in claim 13, wherein the final set of
3   correction parameters (A_p, B_p) is set to be the fourth set of
4   correction parameters if a function of $W^{(4)}(f_T)$ is greater than
5   the function of $W^{(5)}(f_T)$, otherwise the final set of correction
6   parameters (A_p, B_p) is set to be the fifth set of correction
7   parameters.

1   20. The apparatus for I/Q mismatch calibration of a
2   transmitter as claimed in claim 19, wherein the final set of
3   correction parameters (A_p, B_p) is set to be the fourth set of
4   correction parameters if $W^{(4)}(f_T)$ is greater than $W^{(5)}(f_T)$,
5   otherwise the final set of correction parameters (A_p, B_p) is set
6   to be the fifth set of correction parameters.

1   21. The apparatus for I/Q mismatch calibration of a
2 transmitter as claimed in claim 13, wherein the final set of
3 correction parameters (A_p, B_p) is set to be the fourth set of
4 correction parameters if a function of $W^{(4)}(-f_T)$ and $W^{(4)}(f_T)$ is
5 less than the function of $W^{(5)}(-f_T)$ and $W^{(5)}(f_T)$, otherwise the
6 final set of correction parameters (A_p, B_p) is set to be the fifth
7 set of correction parameters.

1   22. The apparatus for I/Q mismatch calibration of a
2 transmitter as claimed in claim 21, wherein the final set of
3 correction parameters (A_p, B_p) is set to be the fourth set of
4 correction parameters if $W^{(4)}(-f_T)/W^{(4)}(f_T)$ is less than
5 $W^{(5)}(-f_T)/W^{(5)}(f_T)$, otherwise the final set of correction
6 parameters (A_p, B_p) is set to be the fifth set of correction
7 parameters.

1   23. The apparatus for I/Q mismatch calibration of a
2 transmitter as claimed in claim 13, wherein the processor
3 further implementing the steps of:
4   further adding an DC compensation parameter γ_p while
5   obtaining the corrected signal $x_c[n]$ such that
6          $x_c[n] = A_p \cdot (x[n] + \gamma_p) + B_p \cdot (x[n] + \gamma_p)^*$;
7   obtaining a first local leakage component measure L_1 from
8   the modulated signal $x_m(t)$ with the final set of
9   parameters A_p and B_p, and the parameter $\gamma_p = \zeta_1$, where
10   ζ_1 is a real number;
11   obtaining a second local leakage component measure L_2 from
12   the modulated signal $x_m(t)$ with the final set of
13   parameters A_p and B_p, and the parameter $\gamma_p = \zeta_2$, where
14   ζ_2 is a real number;

15 obtaining a third local leakage component measure L_3 from

16   the modulated signal $x_m(t)$ with the final set of

17   parameters A_p and B_p, and the parameter $\gamma_p = j\zeta_1$;

18 obtaining a fourth local leakage component measure L_4 from

19   the modulated signal $x_m(t)$ with the final set of

20   parameters A_p and B_p, and the parameter $\gamma_p = j\zeta_2$;

21 obtaining a fifth local leakage component measure L_5 from

22   the modulated signal $x_m(t)$ with the final set of

23   parameters A_p and B_p, and the parameter $\gamma_p = 0$; and

24 obtaining a final DC compensation parameter $\gamma_{p,final}$ based on

25   the first local leakage component measure L_1, the

26   second local leakage component measure L_2, the third

27   local leakage component measure L_3, the fourth local

28   leakage component measure L_4 and the fifth local

29   leakage component measure L_5.

1 24. The apparatus for I/Q mismatch calibration of a

2 transmitter as claimed in claim 23, wherein the final DC

3 compensation parameter $\gamma_{p,final}$ is obtained by

4
$$\gamma_{p,final} = -\frac{1}{2} \cdot \frac{\zeta_2^2(L_1 - L_5) - \zeta_1^2(L_2 - L_5)}{\zeta_1(L_2 - L_5) - \zeta_2(L_1 - L_5)} - j\frac{1}{2} \cdot \frac{\zeta_2^2(L_3 - L_5) - \zeta_1^2(L_4 - L_5)}{\zeta_1(L_4 - L_5) - \zeta_2(L_3 - L_5)}.$$